Mechanically Operable Electrical Device

Background of the Invention

1. Field of the Invention

The present invention relates to a mechanically operable electrical device.

2. Description of the Related Art

Electrical switches comprising of a pair of electrodes which are brought into contact to complete a circuit are well known. A potential problem with some such switches is that repetitive use causes mechanical wear of the electrodes and consequent failure.

In addition, code reading devices are known such that when a coded card to be read is inserted, conductive patches of the card electrically connect selected electrodes of the device to complete electrical circuits. However, due to abrasion by the connecting electrodes, the conductive patches may become worn and lead to incorrect reading of the code.

Brief Summary of the Invention

According to a first aspect of the present invention, there is provided a mechanically operable electrical device, comprising a transmitter electrode, a receiver electrode and a moveable conductive element, wherein: said device is configured such that said conductive element is moveable to a first position remote from said electrodes such that said transmitter electrode is capacitance coupled to said receiver electrode; and said conductive element is moveable to a second position closer to said

electrodes such that said capacitance coupling is reduced.

According to a second aspect of the present invention, there is provided code reading apparatus, and a coded object having one or more conductive regions at defined locations to define a code, wherein said device comprises: a plurality of capacitor devices each having a transmitter electrode and a capacitance coupled receiver electrode; a signal generating device configured to supply a signal of a predetermined type to each said transmitter electrode; and a signal analysing means for analysing a received signal received by said receiving electrodes, wherein said code reading device is configured to receive said one or more conductive regions of said coded object such that the capacitance coupling between the electrodes of one or more corresponding capacitor devices is modified, whereby the signal received at one or more corresponding receiving electrodes is modified.

According to a third aspect of the present invention there is provide a document interpreting system comprising location detection means under which may be placed one or more documents and for detecting the location of pointing means directed at an area of a topmost document of the one or more documents, speech storage means for storing speech relating to different areas of said one or more documents, and speech reproduction means for reproducing speech stored in said speech storage means corresponding to the area of said topmost document to which said pointing means is directed, wherein said pointing means comprises electronic pointing means coupled to said document interpreting system and adapted in use to be directed at any arbitrary area of said topmost document, said location detecting means being arranged to detect electronically the location of said arbitrary area for causing speech stored in said speech storage means

corresponding to the arbitrary area of said topmost document to which said pointing means is directed to be reproduced, wherein said location detecting means comprises a transparent or translucent membrane through which the electronic pointing means is directed at the arbitrary area of said topmost document.

Such a system enables, for example, a user to point to any part of a document which is being read and to obtain a spoken version of any text e.g. words, phrases, sentences, etc in the vicinity of a pointer or a spoken description of any picture in said area. It would also be possible for the spoken version or description to be in a foreign language thereby assisting foreign language learning. It is to be noted that the document being read may be in its original form and does not require any additional matter, e.g. bar codes for its interpretation.

An exemplary embodiment of the invention will now be described with reference being made to the accompanying drawings.

Brief Description of the Several Views of the Drawings

Figure 1 shows an electrical appliance **101** embodying the present invention;

Figure 2 shows an exploded perspective view of components of the linear array of button switches **101**;

Figures 3A and 3B show a front and rear view of the PCB **206** respectively;

Figures 4A and 4B illustrates the operation of the button switch **102**;

Figure 5 shows a diagram of a circuit used to determine the status of the button switches **102** to **105**;

Figure 6 shows signals which illustrate the operation of the circuit of *Figure 5*;

Figure 7 shows an exploded perspective view of components of the rotary switching device **106**;

Figures 8A and 8B show front and rear views respectively of the PCB **704**;

Figure 9 show an alternative rotary switching device **900**;

Figure 10 shows an electronic apparatus **1001** and a card **1002** used with the apparatus **1001**;

Figure 11 shows the code reader 1008 and the card **1002** of *Figure 10*;

Figures 12 and 13 show the facing surfaces of the printed circuit boards **1120** and **1121** respectively;

Figures 14A and 14B show cross-sectional views of capacitor devices of card reader **1008** which illustrate their operation;

Figure 15 shows a diagram of the electronic circuitry **1501** of card reader **1008**; and

Figure 16 shows an alternative card reading arrangement for the toy **1001**.

Figure 17 shows a diagrammatic representation of a document interpretation system in accordance with the present invention;

Figure 18 depicts in greater detail the appearance of a topmost card shown in *Figure 17* which is useful in explaining the operation of the system of *Figure 17*;

Figure 19 shows a block schematic diagram of the document interpretation system of *Figure 17*; and

Figure 20 is a flow diagram relating to the document interpretation system of *Figures 17* and *19*.

Written Description of the Best Mode for Carrying Out the Invention

Figure 1

An electrical appliance **101** embodying the present invention is shown in *Figure 1*. The appliance **100** has a linear array **101** of four manually operable push button switches **102, 103, 104** and **105** which allow a user to select functions of the appliance. In addition, the appliance **101** has a rotary switching device **106** which may be manually rotated to one of five positions to allow a further optional selection to be made.

Figure 2

An exploded perspective view of components of the linear array of button switches **101** is shown in *Figure 2*. Each of the four switches **102** to **105** in the array comprises of a button portion, **202, 203, 204** and **205** respectively. The button portions are configured to be depressed by finger pressure, and they are subject to spring mechanisms (not shown) which return them to their original positions after being pressed and released. The buttons may also be subject to a mechanism which maintains their position after depression, until they are re-pressed. Such mechanisms are known in the art.

The button portions **202** to **204** are manufactured from an electrically insulating material such as a plastics material. An electrically grounded (earthed) conductive element, made from a rectangular piece of metal, is rigidly attached to the rear side of each button portion. Thus, for example,

conductive portion **201** is rigidly attached to the rear surface of button portion **202**.

The linear array **101** of button switches also contains a printed circuit board (PCB) **206**, which defines a capacitor device **212**, **213**, **214**, and **215** for each of the button switches **102** to **105** respectively.

When the button portions are not depressed, the conductive portion **201** is located remotely from the corresponding capacitor device **212**. For example, it may be positioned ten millimetres away. Upon depression of the button portion, the conductive element **201** is relocated to a position relatively near to the capacitor device **212**, for example two millimetres away. The consequential electrical effects on said capacitor device are detected as will be described below.

The conductive element **201** is never brought into contact with electrodes of the capacitor device **212**. To ensure this contact does not take place, the conductive element and/or the electrodes of the capacitor device are covered with an insulating layer, for example, a plastic layer or coating. Alternatively, the movement of the button portion may be mechanically limited to ensure the conductive element cannot make contact upon the PCB.

In an alternative embodiment, the PCB **206** is replaced with a plastic membrane supporting conductive material, such as a conductive ink, defining the capacitance devices and the corresponding tracks providing electrical connections to said devices.

It should be understood that although switch array **101** has been described by way of example to have four button switches, other switch arrays embodying the present invention may be produced with more or less than four such switches. Thus, in the simplest case, the switch array

comprises a single button switch.

Figures 3A and 3B

A front and rear view of the PCB **206** is provided by *Figures 3A* and *3B* respectively.

The capacitor devices **212** to **215** each comprise of a transmitter electrode **302**, **303**, **304** and **305** respectively and a receiver electrode **312**, **313**, **314**, **315** respectively. Each transmitter electrode takes the form of an open circular element which is concentric with a smaller circular element defining the corresponding receiver electrode. Tracks **322** to **325** on the front surface of the PCB provide individual electrical connection to corresponding transmitter electrodes **302** to **305** respectively. The receiving electrodes **312** to **315** are connected to a common track **301** on the rear of the PCB **206** via plated through holes in the PCB. One end of the track **301** terminates in a region **350** of the PCB which supports electronic circuitry for processing signals received by the receiving electrodes.

Hatched areas **351** and **352** on the front and rear of the PCB are electrically grounded. In addition, conductive circular arcs **332** to **335** are arranged concentrically around the capacitor devices **212** to **215** respectively on the front surface of the PCB, and conductive circular arcs **342** to **345** are arranged concentrically around the receiving electrodes **312** to **315** respectively on the rear surface of the PCB. The arcs **342** to **345** and **332** to **335** are also electrically grounded.

The close proximity of the electrically grounded elements **342** to **345** and **332** to **335** ensures that spurious signals received at the receiving electrodes caused by external radiation are kept to within tolerable limits.

Figures 4A and 4B

The operation of the button switch **102** is illustrated in *Figures 4A* and *4B*.

The button switch **102** is shown in the non-pressed configuration in *Figure 4A*. Consequently, the gap between conductive element **201** and the capacitor device **212** is large compared to the relatively small gap of *Figure 4B* where the switch is shown depressed.

During operation of the appliance **101**, a series of square electrical pulses are applied to the transmitter electrode **302** and the resulting signal received at receiving electrode **312** is analysed to determine whether the button switch **102** is depressed or not.

When the moveable conductive element **201** is remote from the device **212**, as shown in *Figure 4A*, the close proximity of the transmitter electrode **302** and the receiver electrode **312** provides sufficient capacitance coupling between said electrodes to allow the signal received at the receiver electrode to be detected. In contrast, when the moveable conductive element **201** is close to the device **212**, as shown in *Figure 4B*, the closeness of said conductive element reduces the capacitance coupling between the transmitter and receiver electrodes such that the received signal is significantly reduced in amplitude.

Example lines of electrical flux **401** and **402**, established during the application of the square pulse to the transmitter electrode **302**, are illustrated in *Figure 4A* and *4B* respectively. The flux lines ***401*** illustrate how an electric field is generated between the transmitter electrode **302** and receiver electrode **312**, when the button switch is not depressed. Whereas, when it is

depressed, the close proximity of the conductive element **201** modifies the electric field such that the flux **402** between the transmitter electrode **302** and the conductive element **201** is increased and that between the transmitter electrode and receiving electrode **312** is correspondingly decreased.

Figure 5

A diagram of a circuit used to determine the status of the button switches **102** to **105** is shown in *Figure 5*. Each of the transmitter electrodes **302** to **305** is connected to a respective low impedance output port OP1, OP2, OP3 and OP4 of a micro-controller **501**. The micro-controller operates under instructions received from read only memory (ROM) **502**. The ROM **502** and the controller **501** may be part of a single application specific integrated circuit (ASIC). The micro-controller is also in communication with an additional memory device, in the form of an EPROM (erasable programmable read only memory) **503**, which may be a plug–in device allowing the operation of the micro-controller to be modified.

The receiving electrodes **312** to **315** of the capacitor devices **212** to **215** are all connected together to the input of analysing electronic circuitry **504**. The circuitry **504** comprises of an amplifier **505**, a bandpass filter **506** configured to filter the output of said amplifier, and a comparator **507**, which takes the output of said filter as its input. The output from the comparator is connected to an input port, IP1, of the micro-controller **501**.

The micro-controller **501** also has four output ports connected to drive circuitry **508** which generates drive signals in response to the output signals received from the micro-controller. The drive signals may energise actuators, heaters, lights etc. (not shown) in accordance with the type and function of

the appliance **101**.

Figure 6

Signals illustrating the operation of the circuit of *Figure 5* are shown in *Figure 6*.

As illustrated by graphs **601** to **604**, the controller **501** sequentially outputs, to the transmitter electrodes **302** to **305**, a square pulse **611** via output port OP1, a square pulse **612** via output port OP2, a square pulse **613** via output port OP3, and then a square pulse **614** via output port OP4. The sequence is then repeatedly repeated.

An example signal received at the receiving electrodes is shown in graph **605** after amplification and filtering by amplifier **505** and filter **506**. The square pulse applied to a transmitter electrode causes charge flow to and from the corresponding receiver electrode. Thus each square pulse generates a positive going pulse **615** to **618** and a negative going pulse **625** to **628** respectively at a receiver electrode.

The filtered signal received at the comparator **507** is compared with a threshold voltage. When the filtered signal is above the threshold voltage a high voltage is supplied to the micro-controller input, and when the filtered signal is below the threshold voltage a low (zero) voltage supplied to the micro-controller input. The graph **606** therefore illustrates the signal received at the input IP1 from the comparator output.

In the present example, it has been assumed that only button switch **104** has been depressed. Consequently, positive going pulse **617** is below the threshold voltage while the other similar pulses **615**, **616** and **618** are above it. In response, the comparator outputs square pulses **635**, **636** and

638 while the comparator input is above the threshold voltage. It may be noted that, due to the finite rise time of the pulses **615**, **616** and **618**, there is a delay between leading edge of the square pulses **611**, **612** and **614** and the corresponding leading edge of the square pulses **635**, **636** and **638**.

Following the output of a square pulse to one of the transmitter electrodes **302** to **305**, the micro-controller monitors the signal level at the input port IP1 for a subsequent predefined period to determine whether the corresponding switch is depressed. For example, following the output of pulse **611** to switch **102**, the pulse **635** received at input port IP1, indicates to the micro-controller that the button switch **102** is not depressed. Whereas, following the output of pulse **613** the voltage on input port IP1 remains low in the subsequent period and thus the micro-controller determines that the button switch **104** is depressed.

Figure 7

An exploded perspective view of components of the rotary switching device **106** is shown in *Figure 7*. A circular disc **701** is rigidly attached to the manually operable part of the rotary switching device such that it is rotatable about its central axis. The disc **701** has a base made from an insulating material with an electrically grounded conductive region **702** on one of its sides. The disc may thus be made in the manner of a printed circuit board. The conductive region **702** has a circular portion **703** located off-centre so that as the disc is rotated the portion **703** rotates about the disc's axis.

The side supporting the conductive region **702** is parallel to and closely spaced from a printed circuit board (PCB) **704** such that they share a common central axis. The PCB **704** contains five capacitor devices **711**, **712**,

713, **714** and **715**, and it is rigidly mounted within the appliance **101**. Consequently, as the disc **701** is rotated it rotates with respect to the PCB **704**, and the conductive portion **703** may be located over each of the five capacitor devices in turn. Preferably, the rotary switching device **106** contains a ratchet mechanism (not shown) so that, when the rotary switching device is rotated and released, the conductive portion **703** is brought to rest directly over a capacitor device.

Figure 8

The PCB **704** is shown in greater detail in the front and rear views of *Figures 8A* and *8B* respectively. Each of the five capacitor devices **711** to **715** have a similar structure to the capacitor devices on PCB **206**. Thus, capacitor device **711** has a small circular receiver electrode **812** surrounded by a transmitter electrode **802**. The transmitter electrode **802** is itself surrounded by an electrically grounded ground electrode **832**. The receiver electrodes of each capacitor device are all connected to a single track **801** via plated through holes in the PCB **704** and tracks **808** on its rear surface.

The rear surface of the PCB **704** has arc shaped ground electrodes **842**, **843**, **844**, **845** and **846**, which are concentric with the capacitor devices **711** to **715** respectively.

As shown in *Figure 8A*, the transmitter electrodes such as electrode **802** form the greater part of a circle but a gap in the circle allows for an extended portion **809** of the ground electrodes, such as electrode **832**, to extend inwards towards the transmitter electrodes, such as **812**. The extended portion of the ground electrodes has a form and position which corresponds to a section of the tracks **808** on the rear side and thus provides

additional shielding for the receiver electrodes.

The effect of the conductive region **703** (shown in *Figure 7*) on the capacitor devices **711** to **715** is the same as that of the conductive element **201** on capacitor device **212**. Thus, for example, when the conductive region **703** is rotated to a position which is remote from the capacitor device **711**, the capacitance coupling between the transmitter electrode **802** and the receiver electrode **812** is relatively high and allows a signal applied to the transmitter electrode to be received at the receiver electrode, and, when the conductive region is rotated to a position which is adjacent to said capacitor device, the capacitance coupling is reduced thereby reducing the amplitude of the received signal.

The rotary switching device **106** is incorporated into a similar circuit to that shown in *Figure 5*, whereby a manual selection, made by rotating the conductive region **703** over a particular one of the capacitor devices **711** to **715**, is received.

In an alternative embodiment, a linear switch array, similar to that shown in *Figure 2*, and a rotary switching device, similar to that shown in *Figure 7*, share a single PCB. Thus the features of PBC **206** and PCB **704** are produced on a single PCB. Advantageously, the receiving electrodes of the switch array and the rotary switching device are connected together. Consequently, the same analysing electronic circuitry and micro-controller may be used to determine selections made at the switch array and the rotary switching device.

Figure 9

An alternative rotary switching device **900** is shown in *Figure 9*. The device **900** uses the same PCB **704** as device **106**. However, the rotatable disc **701** is replaced with an insulating board or sheet **901** which has a fixed location close to, and parallel to, the PCB **704**. For example, in this embodiment the PCB **704** and insulating sheet **901** are separated by 1mm. The sheet **901** is made from a plastics material but in alternative embodiments is made from paper or card. The sheet **901** has five circular regions **902**, **903**, **904**, **905**, **906** on its side facing away from the PCB **704**, that are coated with a conducting material. The conductive material may be a conductive ink, such as a carbon ink, a silver ink or transparent conductive ink, or a conductive paint etc. The positions of the conductive regions **902** to **906** correspond to those of the five capacitor devices **711** to **715**, so that they overlay said capacitor devices.

In common with device **106**, device **900** has a rotatable handle **907** allowing manual selection by its rotation. A sprung electrically grounded electrode **908** is rigidly attached to the handle **907**. The ground electrode **908** has smooth connecting portion **909** which presses against the sheet **901** and which may be brought into contact with any one of the five conducting regions **902** to **906** by rotation of the handle **907**.

During operation, the capacitance coupling between the transmitter electrodes and receiver electrodes of each of the capacitor devices **711** to **715** may be reduced by rotating the ground electrode **908** to a position where it electrically grounds the corresponding conductive region **902** to **906** respectively.

Figure 10

An electronic apparatus **1001** and a card **1002** used with the apparatus **1001** is shown in *Figure 10*. In this instance, the electronic apparatus **1001** is an educational toy for a child.

To use the toy **1001** a card such as the card **1002** is inserted into a slot **1003** in said toy. When it is fully inserted, an image **1009** on the card is viewable through a transparent window **1010** in the upper face of the toy. The toy **1001** is provided with an internal spring loaded arm (not shown) which maintains the position of the card within the slot **1003** while it is being used.

After pressing an "ON" button **1004** a child is able to interact with the toy by indicating selected regions of the card **1002** using a stylus **1005**. This is achieved by receiving signals at an electrical receiver located in the stylus tip **1006** that are transmitted by a matrix of linear electrodes within the toy **1001**. Devices having such position detection means are known in the art.

The card **1002** is one of many cards which may be used in co-operation with the toy **1001**. Therefore, in order to operate correctly, the identity of the card **1002** must be provided to the toy **1001**. For this reason, the card **1002** has an identifying code **1007** arranged along an end portion of the card, and the toy **1001** has code reader **1008**. The code reader 1008 receives the end portion of an inserted card and identifies it from the identifying code **1007**.

The toy **1001** and card **1002** provide an example of the present invention. However, it should be understood that other portable objects supporting code defined by conductive elements may be used with code reading apparatus operating in accordance with the present invention. For example, the code reading apparatus may form part of a security device,

such as a door lock, requiring the insertion of a card having a particular code in order to be activated.

Figure 11

The code reader **1008** and the card **1002** of *Figure 10* are shown in *Figure 11*. The identifying code **1007** comprises of a series of conductive pads linearly arranged adjacent the edge **1101** of the card **1002**. Cards, such as card **1002**, have eight regions **1111** to **1118** inclusive, reserved for the possible application of a conductive pad. One or more of the conductive pads are applied to the card as conductive ink, or paint, during their production. Preferably, the card is subsequently laminated or coated with an insulating protective layer of, for example, a plastics material. (The protective layer **1400** is shown in *Figures 14A* and *14B*). Thus the ink is protected from abrasion during use.

The cards, such as card **1002**, are individually identifiable by the presence or absence of conductive ink in each of the reserved regions **1111** to **1118**. For example, the pattern of the conductive pads may be considered to define a binary code number which identifies the card. For example, card **1002** has a conductive pad at regions **1111**, **1113**, **1116**, **1117** and **1118** while regions **1112**, **1114** and **1115** are devoid of conductive material. Thus, the conductive pads on card **1002** define the binary number 10100111, or 167 in base ten. In this way, using eight reserved regions and at least one conductive pad on each card, two hundred and fifty-five different cards may be identified. Alternatively, the cards may have different images on each of their faces so that they may be used either way up. In this case, each face of the card is identified by the identifying code **1007**. For example, if card **1002**

were turned up side down and edge **1101** inserted into card reader **1008**, it would present the binary number 11100101 (two hundred and twenty-nine in base ten) to the card reader. i.e. the reverse of binary number 10100111. Thus, the two faces of the card are individually represented by a single identifying code.

The card reader **1008** comprises of two printed circuit boards **1120** and **1121** spaced apart by spacers **1122**. The gap between the PCB **1120** and the PCB **1121** is sufficiently wide to provide a loose fit for the end portion of cards, such as card **1002**. Typically, the gap is between two millimetres to five millimetres wide, and preferably it is two millimetres to three millimetres wide. The upper surface **1123** of PCB **1120** is conductive and electrically grounded to provide shielding for receiver electrodes located on it lower surface.

Transmitter electrodes are located on the upper surface of the PCB **1121**, and in combination with the receiver electrodes they define eight capacitor devices. Each capacitor device is positioned to receive one of the reserved regions **1111** to **1118** when a card is inserted. The reduction of conductance coupling in one of said capacitor devices, caused by the presence of a conductive pad, allows the card reader **1008** to determine its presence.

Figures 12 and 13

The facing surfaces of the printed circuit boards **1120** and **1121** are shown in *Figures 12* and *13* respectively. PCB **1120** has eight circular receiver electrodes **1201** to **1208** inclusive, which are linearly aligned and equally spaced. The PCB also supports signal analysing circuitry within a

region **1210**, and all the receiving electrodes **1201** to **1208** are connected to said circuitry by a single conductive track **1209**. A grounded electrode **1211** (shown hatched) surrounds the receiving electrodes **1201** to **1208** and the conductive track **1209**, to provide further shielding for the receiving electrodes from electromagnetic noise.

As shown in *Figure 13*, the upper surface of PCB **1121** has eight square shaped transmitter electrodes **1301** to **1308** inclusive. The eight transmitter electrodes are positioned such that they face the receiver electrodes **1201** to **1208** when the card reader **1123** is assembled. The transmitter electrodes are connected to terminals **1309** by plated through holes in their centres and conductive tracks on the reverse side of the PCB **1121** (illustrated by dashed lines **1310**). A ground electrode **1311** surrounds the transmitter electrodes to provide further screening from electromagnetic noise.

Figure 14A and 14B

The operation of capacitor devices of card reader **1008** is illustrated in the cross-sectional views of *Figures 14A* and *14B*. *Figure 14A* shows the capacitor device defined by transmitting electrode **1302** and receiving electrode **1202** while reading card **1002**. In operation, a square pulse is applied to the transmitter electrode **1302** via a conductive track **1310**. In the absence of a conductive pad, the capacitance coupling between said electrodes remains relatively high, and consequently a relatively high signal is received at receiving electrode **1202**.

Figure 14B shows the capacitor device defined by transmitting electrode **1303** and receiving electrode **1203** while reading the same card,

1002. In this instance, a conductive pad **1401** is present between said electrodes and, consequently, the capacitance coupling between them is reduced to a relatively low value. Therefore, when a square pulse is applied to the transmitter electrode **1303**, the presence of the conductive pad **1401** causes a relatively low signal to be received at receiving electrode **1203**.

Thus, by supplying a square pulse to each of the transmitting electrodes **1301** to **1308** in turn, and monitoring the amplitude of the pulse received at receiving electrodes, it is possible to determine the identifying code on the currently inserted card.

Figure 15

A diagram of the electronic circuitry **1501** of card reader **1008** is shown in *Figure 15*. Many of the components of circuit **1500** are the same as those of *Figure 5* and operate in a similar manner. Thus, circuit **1500** has a micro-controller **1501**, in communication with a ROM **1502** and an EPROM **1503**. The EPROM **1503** may be configured to be replaceable, so that a particular EPROM which is designed for use with a particular set of cards may be used.

The micro-controller **1501** also receives digital signals from analysing electronic circuitry **1504**, itself comprising an amplifier **1505**, a bandpass filter **1506** configured to filter the output of said amplifier, and a comparator **1507**.

Eight output ports of the micro-controller **1501** are each connected to one of the transmitter electrodes **1301** to **1308**. The receiving electrode **1201** to **1208** are all connected to a single input of amplifier **1505**.

A ninth output port of micro-controller **1501** is connected to amplifier **1510** which provides signals to an audio speaker **1511**. Thus, in response to

the identification of a card, signals relating to the card are supplied to the amplifier **1501** in accordance with data stored in EPROM **1503**.

The operation of the circuit **1500** is essentially the same as the circuit of *Figure 5*. Thus, the micro-controller **1501** supplies a square pulse to each transmitter electrode **1301** to **1308** in turn, and in a following period, it monitors the signal received from comparator **1507**. Signals received by receiving electrodes are amplified by amplifier **1505** before being filtered by bandpass filter **1506**. The comparator **1507** determines whether the signal goes above a threshold value, and if so then a high output is supplied to microprocessor **1501**. Consequently, the micro-controller is able to determine the presence or absence of a conductive pad in each of the regions **1111** to **1118** of a card, and thus determine the identity of said card.

Figure 16

An alternative card reading arrangement for the toy **1001** is illustrated by *Figure 16*. A PCB **1601** has essentially the same structure as PCB **1120** except that it contains ten receiving electrodes, instead of eight. However, unlike the card reader **1008**, the corresponding transmitting electrodes **1603** are printed onto a flexible plastic membrane **1602**. As well as forming a part of the card reading arrangement, the plastic membrane supports the matrix of linear conductors which are used in co-operation with the stylus **1006** to provide an X-Y position sensing device.

Thus when a card is initially inserted, or the toy is first switched on, signals are supplied via the linear conductors to the transmitter electrodes to identify the card. Having identified the card the matrix is then used in the position sensing mode.

In a further alternative card reading arrangement for the toy **1001**, the PCB **1601** is replaced with an extended portion of plastic membrane **1602**. Receiving electrodes are printed onto the extended portion, and the membrane is folded such that each of the receiving electrodes is positioned opposite one of the transmitting electrodes **1603**. The membrane is folded such that a suitable gap is provided between the receiving electrodes and transmitting electrodes for receiving a card such as card **1002**. This alternative arrangement operates in the same manner as those of *Figure 10*, or *Figure 16*, but has the advantage of not requiring a PCB to provide the transmitting and receiving electrodes.

The receiving electrodes and transmitting electrodes are separated by a gap produced by the folding.

Figure 17

For effective learning, particularly of language, it is most helpful for a student to have the advantage of considerable attention, if not full time attention, of a teacher. For example, a young child will often learn to read by looking at a book containing pictures and corresponding words with an adult reading the words as the child follows the words and looks at the associated pictures. Thus the mind of the child is focusing on an image depicting something, is being given the spoken word and is seeing the written word. Furthermore, from the context the child is absorbing the word within the scope of a grammatical structure and is gathering the meaning, either from the pictures if relevant or with the aid of an explanation. At any stage the teacher can discuss with the child any word or its meaning or draw to the child's attention a similar word and provide explanations and definitions of

grammar and meaning, i.e. syntax and semantics.

Similarly, when a child is beginning to read, the adult can monitor the reading and provide immediate feedback on a one-to-one basis to maximise the rate at which the child gains reading skills and remembers vocabulary. The interest and motivation of the child can be maintained at high levels.

However, apart from a domestic situation, the cost of such teaching techniques makes them prohibitive, yet there is a very substantial need for such additional support, particularly in the areas of adult illiteracy, foreign language teaching and remedial language teaching.

Furthermore, similar needs for feedback and flexible recapitulation of concepts, explanations and facts are needed in many of the areas of education including mathematics and other science subjects. The availability to a student, of a teacher who can be requested to repeat an explanation, elaborate on some point of commentary or deal with any other relevant question is an extremely valuable resource in many situations.

It is known to students with e.g tape recordings of an explanation. When such recordings are applied to the process of learning to read, a simple system is one in which a tape recording of a printed work is given to a student and then student has the opportunity of following the words, repeating segments of the tape recording and indeed recording his or her own attempts at reading the words and comparing with the tape recordings of the tutor. However, such a system is inflexible and hard to operate.

One published approach to the teaching of language is contained in PCT International Publication No. WO 83/02188 (MERIT BOND LIMITED) wherein printed text is provided with bar codes associated with at least some of the text, a manually controlled reading device being used to access the bar

codes as the user may require, and an electronic processing means used to cause the apparatus to synthesise voice reproduction corresponding to the text with which the selected bar code is associated. Such a device has limitations in terms of functions fulfilled and in the special preparation required of the printed material, i.e. it can not be used with conventional books.

Another published approach, (PCT WO 87/06752) in the teaching of language is one in which sets of bar codes are arranged on respective lines corresponding to lines of printed text. Each bar code set, when accessed, causing a particular storage location from a message store to be accessed to be reproduced by a speech producer. The limitations of such a system are that a book can not be used in its original format, since bar codes have to be added or overprinted onto the original document at the expense of text. Further, the selection of the bar code set may lead to confusion and small children may have difficulty scanning a bar code.

Yet another published approach (PCT WO 90/15402) relates to a document interpreting system comprising location detecting means on which a plurality of documents to be interpreted may be stacked and for detecting through said documents the location of pointing means directed at an area of the topmost document of said stack, speech storage means for storing speech relating to different areas of said documents and speech reproduction means for reproducing speech stored in said speech storage means corresponding to the area of said topmost document to which said pointing means is directed. In the system disclosed, the pointing means takes the form of a user's finger.

Another published approach (EP 0 572 466) relates to a document interpreting system comprising location detecting means on which a book or other stack of documents may be placed and electronic pointing means coupled to said location detecting means and adapted in use to be directed at an arbitrary area of the topmost document of the stack of documents, said location detecting means being adapted to detect electronically through said stack the location of said arbitrary area to cause speech stored in a speech storage means associated with said arbitrary area to be reproduced.

A disadvantage with the document interpreting system of EP 0 572 466 is that if the stack of documents, for example the pages of a book, contain documents with metallic embossing or if the humidity of the stack of documents is high then there is considerable distortion in the location detection process leading to a shift in the detected position of the pointing means which can lead to speech associated with an incorrect arbitrary area being reproduced.

The present embodiment is directed to a document interpretation system which overcomes the above limitations and provides for a practical and useful device which eliminates the need for specially printed codes associated with the words and phrases of the written material an enables a wide variety of normal books to be used including those having metallic embossing or documents having high humidity.

The document interpreting system depicted in *Figure 17* of the drawings is especially applicable for assisting learning of reading or pronunciation or understanding of words, phrases or sentences or interpretation of drawings, pictures, etc. It should be understood that the term "document" covers any printed matter or indeed any written or drawn

matter, and in particular includes books.

The document interpretation system comprises a membrane **1701** which overlies a cartridge **1702** in which are located one or more cards **1703** in the form of a stack. The card to be read by the user (not shown) is placed as the topmost card **1704** where more than one card is present. The cartridge **1702** and membrane **1701** are shown as schematically in *Figure 17*. In practise, the membrane **1701** may be housed in a frame formed as part of the upper surface of the cartridge **1702** of fixedly located on, or hinged to the upper surface of the cartridge **1702** by any suitable means. The important aspect is that the membrane **1701** is located in use, or may be brought into location for use, such that it overlies the card or cards **1703** stored in the cartridge **1702**.

The membrane **1701** is transparent or at least sufficiently translucent as to allow the user to determine the contents of the topmost card **1704** when viewing through the membrane **1701**. The membrane **1701** comprises a grid **1705** formed of conductive stands creating an X-Y pattern dividing the membrane **1701** into substantially squared shaped segments.

The membrane **1701** is formed from a pair of transparent films, one of which defines a set of parallel conductive strands in a first (X) direction, and the second film defining conductive strands in a second (Y) direction perpendicular to the first direction. The transparent films are Orgacon Conductive Transparent Films and the conductive strands are defined by screen printing of Strupas ink. The Orgacon films and Strupas ink are supplied by Agfa-Gevaert N.V., of Mortsel, Belgium.

The membrane **1701**, and specifically the grid **1705**, is electrically coupled to a printed circuit board (PCB) **1709**. The PCB **1709** has mounted

thereto an Application Specific Integrated Circuit (ASIC) **1711**. The PCB **1709** is further provided with a power source in the form of a battery **1710** and a speaker **1712**. The PCB **1709** may be formed as part of the cartridge **1702**, as part of the frame housing the membrane **1701**, or as part of a separate unit.

The ASIC **1711** is provided with its own power source in the form of a battery **1708**. Alternatively, the ASIC **1711** may be powered directly from the PCB battery **1710**.

A pen or pointer **1706** is coupled to the PCB **1709** by means of a cable **1707**. The pointer **1706** is adapted to be pointed at an area of the membrane **1701** coincident with a arbitrary area of the topmost card **1704** viewed through the membrane **1701** so as to enable the co-ordinate location of the arbitrary area to be detected by the membrane **1701** and in turn determined by the ASIC **1711**.

The pointer **1706** is, for example, magnetically or capacitively coupled to the membrane **1701** in use. Importantly, since the relative positions of the membrane **1701** and the pointer **1706** are determined magnetically or capavitively rather than by pressure applied to the membrane **1701**, the document interpretation system finds particular application for use with young children who are apt to press randomly and unintentionally on the membrane **1701** whilst using the system. With a membrane activated by pressure such contacts would lead to a large number of false readings and hence confusion to the user.

The ASIC **1711** contains machine code and/or software programs and solid state circuitry to control operation of the pointer **1706**, membrane **1701** and speaker **1712**. In addition, the ASIC **1711** stores speech associated with

areas of the cards **1703**.

In use, the output from the grid **1705** of the membrane **1701**, consisting of the co-ordinate details of an area of the card **1704** to which the pointer **1706** is directed, is fed to the ASIC **1711** on the PCB **1709**. The machine code and/or other software encoded in the ASIC **1711** resolves the co-ordinate details from the membrane **1701** and determines the speech stored in the ASIC **1711** which is associated with the area of the topmost card **1704** to which the pointer **1706** is directed.

It will be appreciated by those skilled in the art that the location of the card **1704** or other document to be read, relative to the membrane **1701**, may be established by, for instance, physical means such as the internal dimensions of the cartridge **1702** to ensure the card is placed in a known location relative to the overlying membrane **1701**. Alternatively, the card **1704** or other documents may be placed in the cartridge **1702** in any orientation and known features such as corners of the card **1704** may be registered by pointing at them through the membrane **1701** with the pointer **1706** in an initialising registration procedure. By this method the location of the words and pictures, etc. may be calculated by such known means as simple co-ordinate geometry routines.

In addition, it will be appreciated that the ASIC **1711** will need to determine which of the cards **1703** is the topmost card **1704**. This may be done, for example, by providing a unique identifier area on each card **103** to which the pointer **1706** is first directed. By arranging for each card **1703** in the stack to have its identifier area in a different position, the ASIC **1711** is able to determine the identity of the topmost card **1704**. Alternatively, a manual mechanism may be provided wherein the PCB **1709** is provided with

an input terminal by which the user may enter an identifier, e.g and alpha-numeric character or characters, to identify the topmost card **1704**.

In use of the system thus far described, a user points the pointer **1706** at an area at the topmost card of the stack of cards **1703**, e.g some printed text or a picture. The grid **1705** of the membrane **1701** detects the presence of the pointer **1706** by means of the magnetic or capacitive changes in the grid **1705** of the membrane **1701** caused by the proximity of the pointer **1706**. The membrane **1701** outputs signals representing the co-ordinates of the designated area to the ASIC **1711**. The machine code or software program embedded in the ASIC **1711** processes the signals and resolves the corresponding co-ordinates and generates a signal instructing the speaker **1712** to output an audio signal corresponding to speech corresponding to the printed text pointed to on the card **1704** or alternatively corresponding to the picture pointed to on the card **1704**.

Optionally, the user of the system can access a button or switch either on, for example the stylus to give a real voice reply of individual words when touched by the pointer **1706**. Alternatively, another button may be provided which when accessed causes reproduction of the whole sentence when the first or any word in that sentence is touched by the pointer **1706**. Another button may be provided which when accessed allows the user to receive prompts, such as a suggestion to look the syllables within the word selected or the system can be set up to sound out the word phoneme by phoneme. A further button may be provided which, when accessed by the user, will give an explanation of the word or picture which may be in terms of its definition, mode of usage or other commentary.

The system may also be used for teaching a second language, in which case, for example, a sentence can be reproduced in both languages in the correct idiom for each language using two different buttons, e.g on the cartridge **1702**. Each word can also be represented in each language, word for word, by the selection an appropriate button. Where complex multi-syllable foreign words are being taught, the word may be represented both in its normal presentation at normal dictation speed and also by a further selection at a slowed down speed enabling the student to dissect the pronunciation of the word, syllable by syllable.

Figure 18

Some examples of the use of the system described with reference to *Figure 17* will now be described with reference to *Figure 18* which depicts the topmost card **1704** of *Figure 17* in greater detail.

Referring to *Figure 18*, a rectangular area **1801** is reserved on cards **1703** for displaying a unique identifier. Thus card **1704** has a unique identifier **1802** within the area **1801**. Consequently, using pointer **1706** of *Figure 17* to point to rectangular area **1802** identifies card **1704** to the document interpretation system of *Figure 17*.

Using pointer **1706** to point to area **1803** would cause the sentence "K is for Katie kangaroo" to be reproduced. Pointing to area **1804** may cause the phrase "hello I am Katie kangaroo" to be reproduced.

Pointing in each of the areas **1805** to **1813** inclusive would cause the individual words "kangaroo", "kitten", "Kite", "Orange", "K", "is", "for", "Katie" and "Kangaroo", respectively, to be reproduced.

It should be appreciated that the rectangular areas referred to in *Figure 18* are used by a way of example only and other shaped areas, such as a circular shaped areas may be used.

Figure 19

In *Figure 19* of the drawings, there is shown a block schematic diagram relating to the document interpretation system of *Figure 17*. This comprises the membrane **1701** which affords and output **1908** to the PCB **1709**, which is itself connected to the pointer **17806** via the cable **1707** and to the speaker **1712**.

The PCB **1709** has mounted thereon the ASIC **1711** which typically comprises a microprocessor **1930** which operates under the control of a program stored in read only memory "ROM" **1931** and receives the signals representing the co-ordinate details via output **1908** from the membrane **1701**. A random access memory (RAM) **1932** is provided in which is stored the speech signals corresponding to the various areas of the documents being read, e.g the cards **1703**. The micro processor **1930** outputs the speech signals to the speaker **1712**, via an input/output (I/O) interface **1933** which causes the speech signals to be reproduced by the speaker **1712**.

It is envisaged that that random access memory **1932** may take the form of a removable RAM-card in which the various speech signals are stored corresponding to the different areas if the cards **1703**, thereby enabling a set of cards **1703** and associated RAM-card to be sold as a package.

Figure 20

In *Figure 20* of the drawings there is shown a flow diagram of a typical operating system of the arrangement depicted in *Figure 19*. At step **2001**, the micro-processor **1930** monitors the membrane **1701** for new data. The new data is decoded at step **2002** to obtain the corresponding speech signal stored in the RAM **1932**. At step **2003**, the speech signal is output to the speaker **1712**, the output of which is monitored by the micro-processor **1930** via the I/O interface **1933**, at step **2004**, to determine the conclusion of the speech signals corresponding to the selected area. The system is then ready for re use.

It will be appreciated that new cards, or locally generated documents, e.g. flash cards and picture stories, may have their textual and pictorial co-ordinates recorded by means similar to that of *Figure 17* with the system operating in a "writing" mode. In this mode the co-ordinates of individual words, pictures, phrases, etc. are read, via the pointer **1706**, from cards placed in the cartridge **1702** under the membrane **1701** by the program in the read only memory **1931** (*Figure 19*). These co-ordinates are then converted into the corresponding speech signals stored in the random access memory **1932** for subsequent use in the "reading" mode described above.

The document interpreting system which has been described is advantageous in that it enables normal printed or written documents to be "read" without special overprinting of bar codes, magnetic codes, etc. The system can also operate with documents containing metallic embossing or having pages with high humidity content. RAM-cards and sets of cards **1703** may also be sold as a package in respect to particular items for use by teachers, pupils, etc. on equipment in many different locations.

It should be appreciated that the document interpreting system which has been described has been given by a way of example only and various modifications may be made dependent upon any particular application. Although the pointer **1706** has been shown as connected to the PCB **1709** by means of a cable **1707**, it may be remotely connected to it using, for example, an infrared, radio or other link. Also, although the use of an ASIC **1711** in conjunction with a speaker has been described, other speech storage systems may be used, such as using tape or compact disk and associated player. Other output devices may also be used such as headphones.

Further, whilst the set of cards **1703** has been described as being stored in a cartridge **1702**, other means of locating the cards **1703** relative to the membrane **1701** may be utilised, for example, by clipping or otherwise temporarily fixing the card **1704** or cards **1703** to the underside of the membrane **1701**.

Further, a mechanism may be provided to enable the cards **1703** in the cartridge **1704** to be shuffled so as to change the identity of the topmost card **1704**. For example, an aperture may be provided in the cartridge **1702** to allow the stack of cards **1703** to be removed, manually shuffled and reinserted into the cartridge **1702**.

The system may also be used with documents other than individual cards **1703**. For example, the system may be used with complete books wherein the membrane **1701** is placed over each page of the book in turn. Advantageously, means may be provided, such as a book stand, for holding the book at rest with the membrane **1701** hinged thereto such that the membrane **1701** may be hinged upwards away from contact with the page of

the book to allow for the pages to be turned. The membrane **1701** may then be hinged back down into contact with the subsequent page of the book.

Another form of document that may be used with the system is a scroll comprising an elongate document wound onto one or a pair of rollers. In use, the roller or rollers can be rotated so as to bring the required portion of the document into line with the membrane **1701**.

Further, while it is important that the membrane **1701** is transparent or at least translucent, the membrane **1701** may be manufactured to be flexible or inflexible. In particular, where the membrane **1701** is flexible, a separate strengthening member may be provided, for example, a frame to stiffen the membrane **1701**.